Advanced EO Sensors for UAV Applications

By

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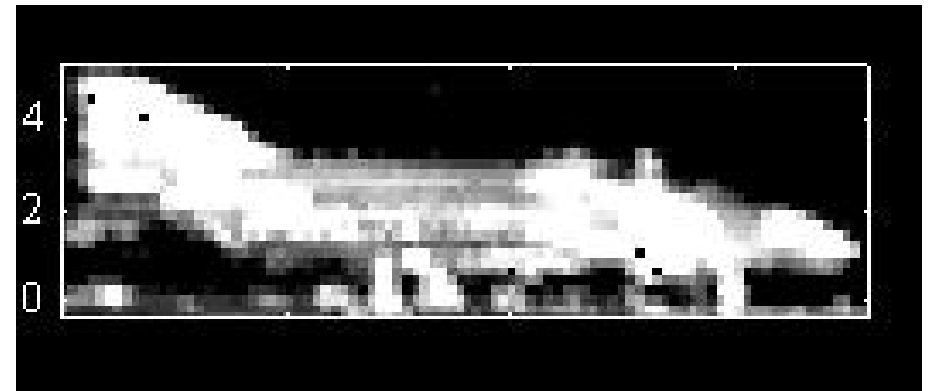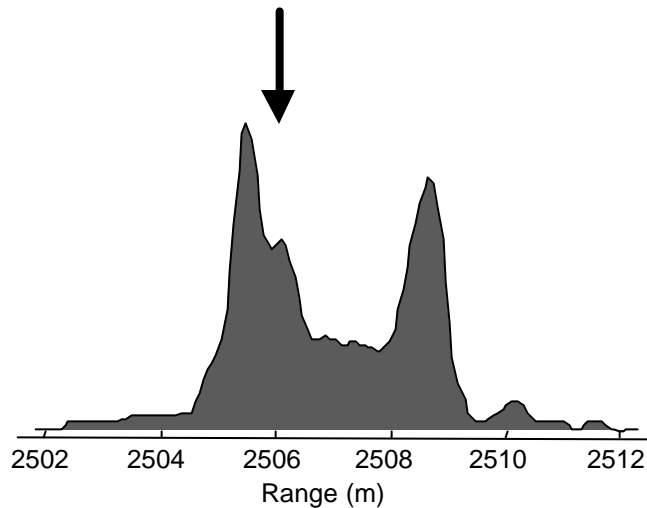
Adding Dimensions Makes a Difference
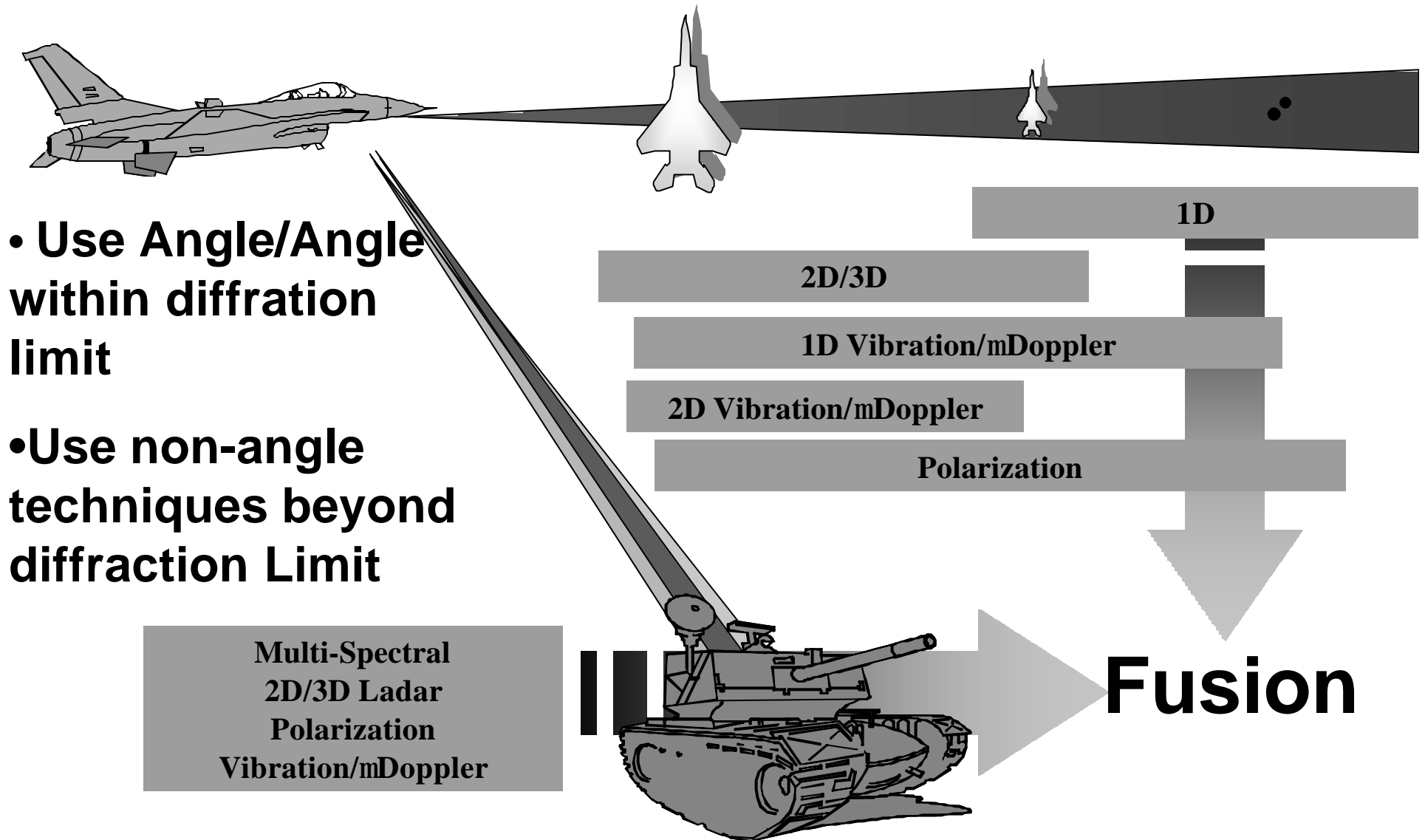

High Res. 1D image

Range (m)

Lower Res. 2 D Image

Which Would you Rather Have???

Laser Radar Multi-discriminant Detection & ID

• **Use Angle/Angle within diffration limit**

•**Use non-angle techniques beyond diffraction Limit**

1D

2D/3D

1D Vibration/mDoppler

2D Vibration/mDoppler

Polarization

**Multi-Spectral
2D/3D Ladar
Polarization
Vibration/mDoppler**

Fusion

Why do I Need More Dimensions?

- Difficult Targets
  - Under foliage or camouflage
  - Underground facilities
  - High clutter backgrounds
- New Targets
  - Chem. / bio.
- Bomb Damage Assessment (BDA)
  - Do I need to re-strike?
- High Confidence Target ID
  - The political environment no longer allows mistakes

THERMAL SPECTRAL IMAGING

- **Passive spectral sensors have the potential for detecting and characterizing camouflaged and concealed targets in clutter**
  - **Clutter suppression** ➧ detect low contrast targets
  - **Low false alarm rate** ➧ color discrimination
  - **Relaxed spatial resolution** ➧ broad area coverage
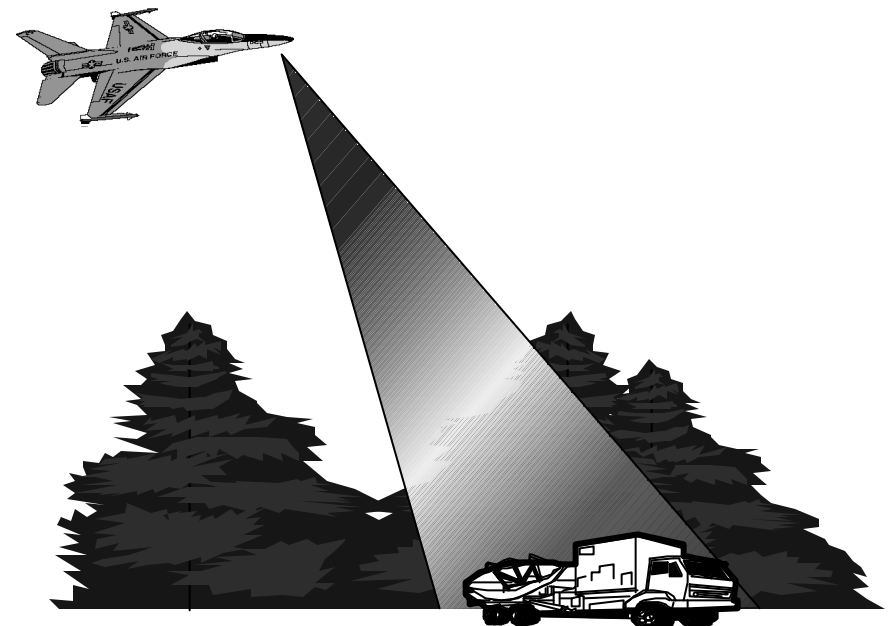 - **Material identification** ➧ target characterization

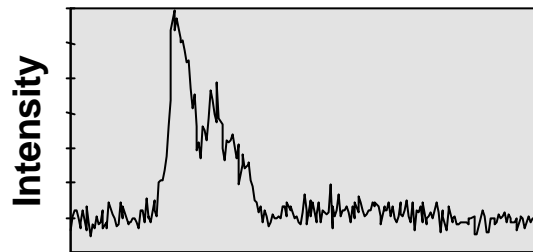**Target size**

FLIR pixel size

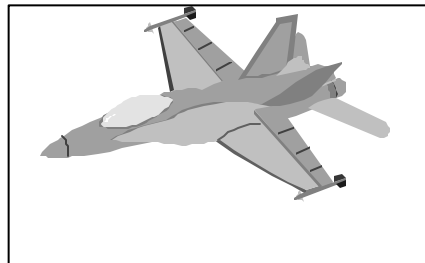**Spectral sensor pixel size**

1D, 2D, & 3D Ladar ID

1-dimensional	2-dimensional	3-dimensional
Range profile (x)	(x,y) TV-like picture	All points in image have (x,y,z) information
Data interpreted by computer	Data interpreted by human or computer	Most robust data interpretation by computer/human

High Range Resolution Laser Radar

1D LADAR Signature

1D LADAR

60+ km Path

nose, cockpit, engine, wing, skate, stabilizer

- Long Range Target ID
- Temporal Imaging
- Effective Beyond Imaging Limit
- Range-Reflection Profile/Projection
- ATR/Reconstruction
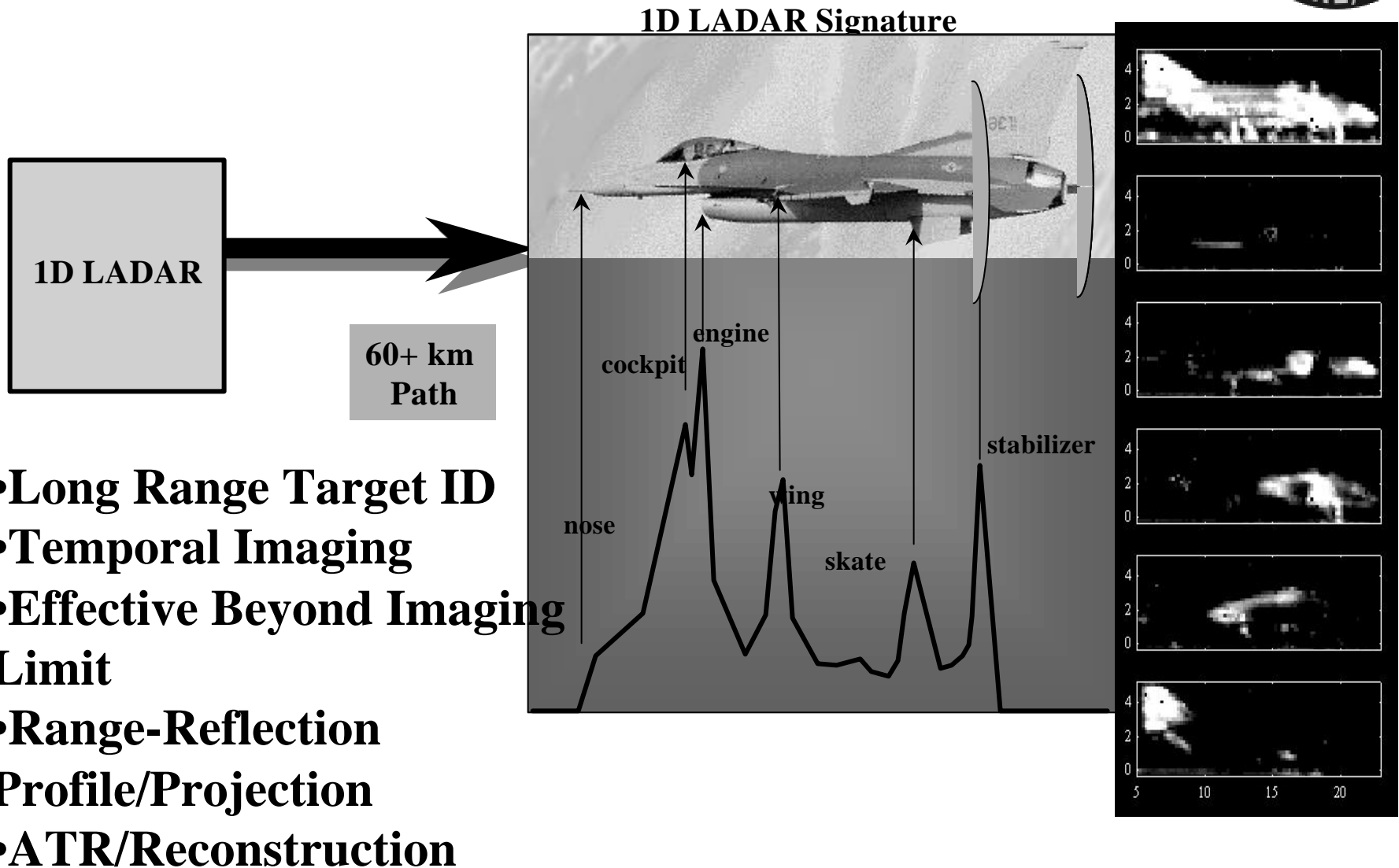
FLIR / 2D Ladar Breadboard
Side-by-Side Comparison
Imagery Collected With Identical Range/Targets
(Different Dates)

NFOV FLIR Image

2D Ladar Image

- 8-inch Aperture
- State-of-the-Art FLIR
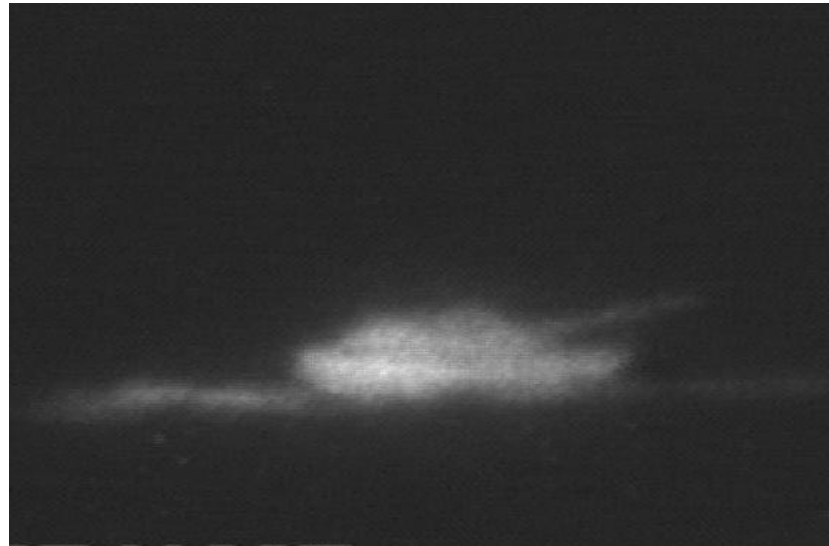- 8 - 12 micron waveband
- 6 nmi Range (WSMR)

- 8-inch Aperture
- 40 mJ Eye safe Laser
- 6 nmi Range (WSMR)
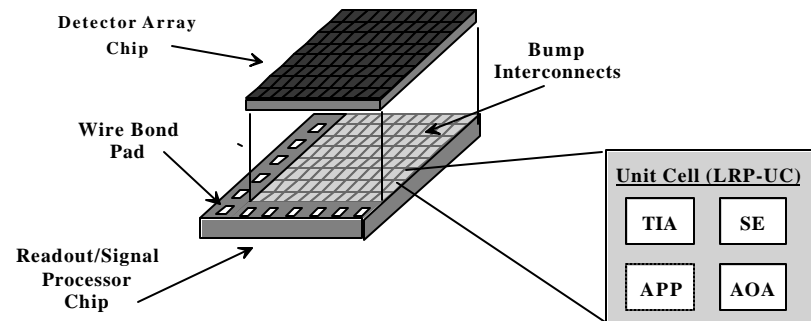
Laser Radar 2D
(angle / angle) Imaging

Laser radar Image of a
Tank at 16 Km
(20 cm aperture)

3-D FPA Imager

- Single pulse per image
- Real-time images (30 Hz)
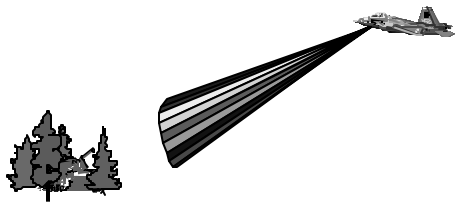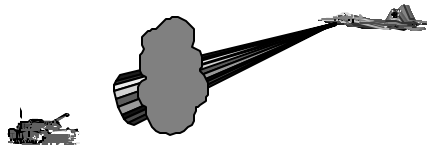- 32x32 pixel arrays
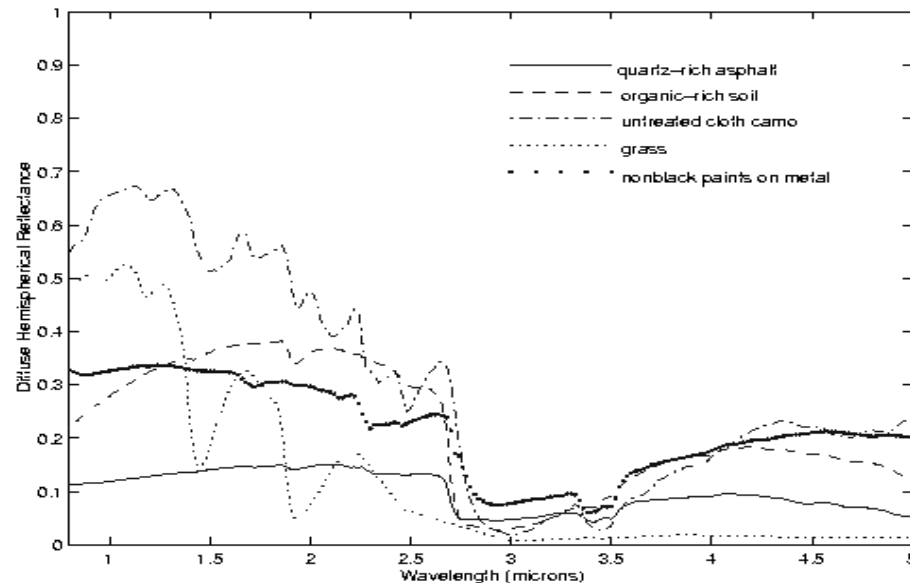- Images displayed real-time) in false color

Detector Array Chip

Bump Interconnects

Wire Bond Pad

Readout/Signal Processor Chip

Unit Cell (LRP-UC)

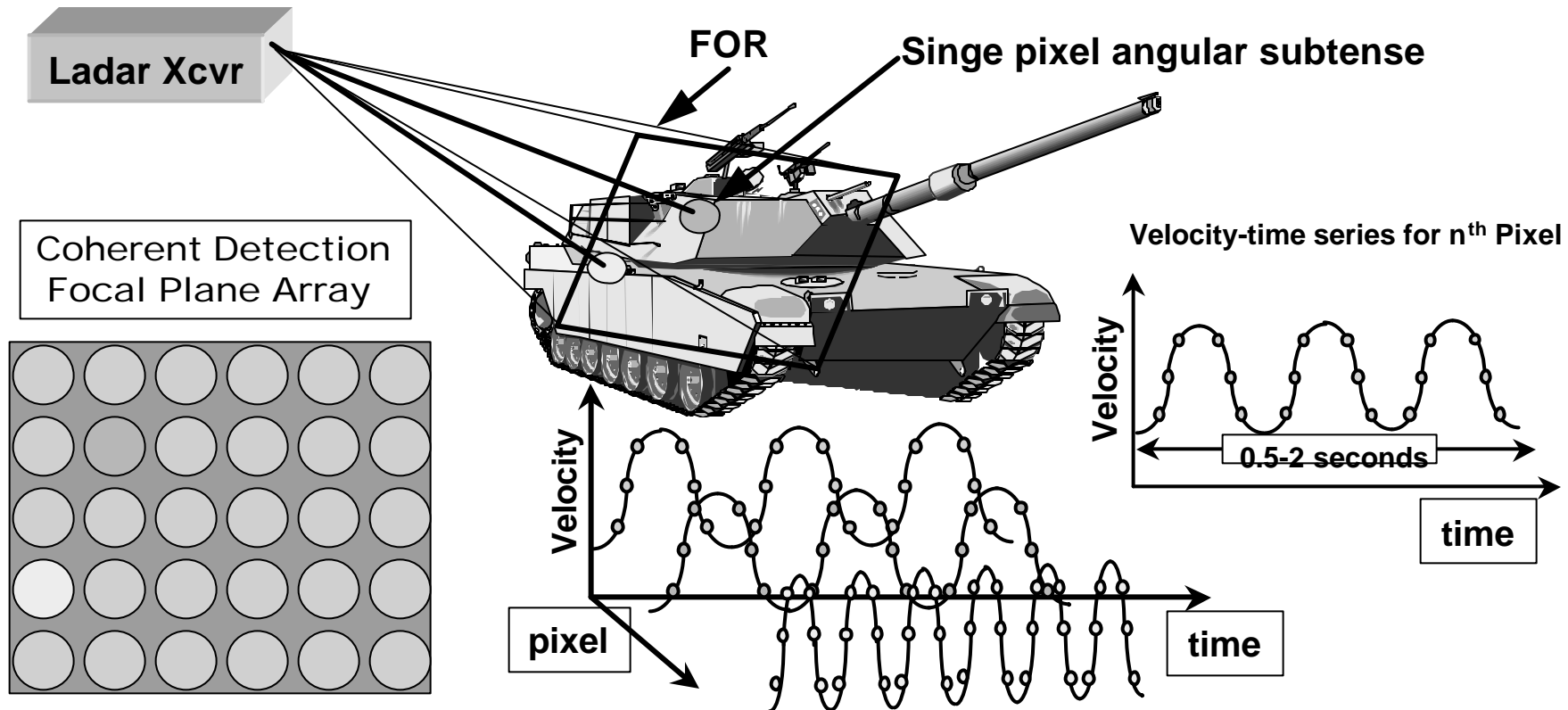| TIA	SE
APP	AOA

Multispectral Laser Radar

- ID & BDA of mostly concealed targets
  - Obscured angle /angle image still ID'd
- Better S/N and less sensitive to ambient conditions (compared to passive)
- Relaxed spatial resolution requirements
- Smoke and weather penetration
- Potential for exhaust cloud typing

ID & BDA vs. obscured targets
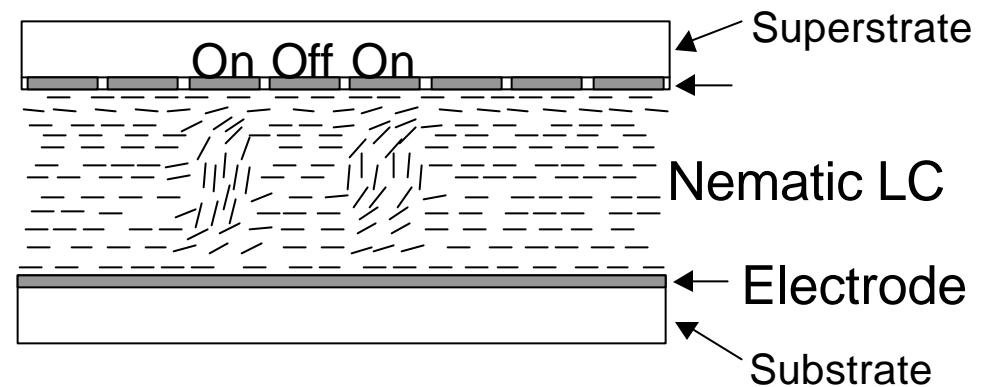
-Smoke Penetration
-Chem. / Bio Detection
- ID exhaust cloud

Legend:
- quartz–rich asphalt
- organic–rich soil
- untreated cloth camo
- grass
- nonblack paints on metal

Y-axis: Diffuse Hemispherical Reflectance
X-axis: Wavelength (microns)

Vibrational Imaging

Ladar Xcvr

FOR

Singe pixel angular subtense

Coherent Detection Focal Plane Array

Velocity-time series for n[th] Pixel

Velocity

0.5-2 seconds

time

Velocity

pixel

time
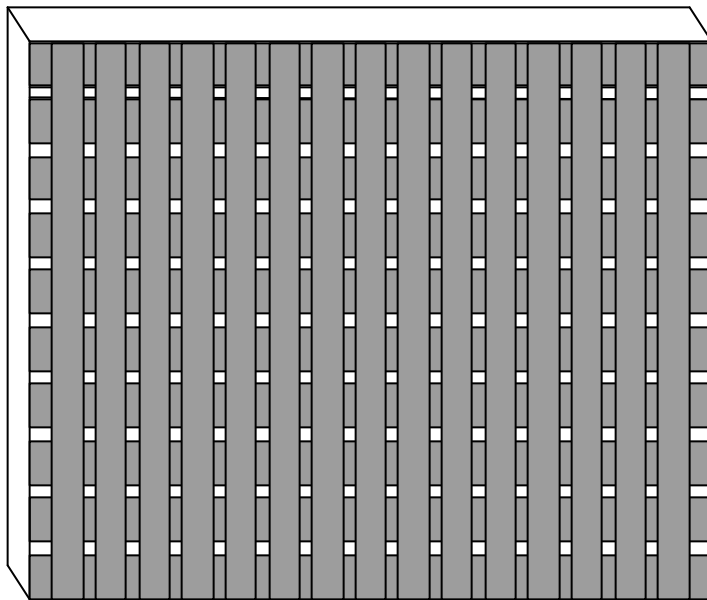
- **Time required for non-multiplexed pixels: N*(0.5-2 sec) » 30 sec - 1 minute!**
- **Time required for multiplexed pixels: ~ 0.5-2 seconds**
- **Scanner requirements are also less stringent for multiplexed pixels**

Space Fed Optical Phased Array

(One Dimensional Beam Steering at a Time)

Unfolded Phase Profile

Individual Phase Shifters

Undisturbed phase front

Molecular reorientation with E field.

Phase Shift

2π

0
0

RMS Voltage

On Off On

Superstrate

Nematic LC

Electrode

Substrate
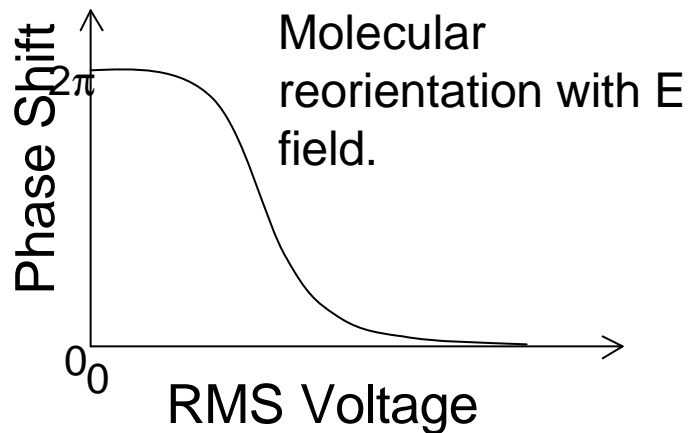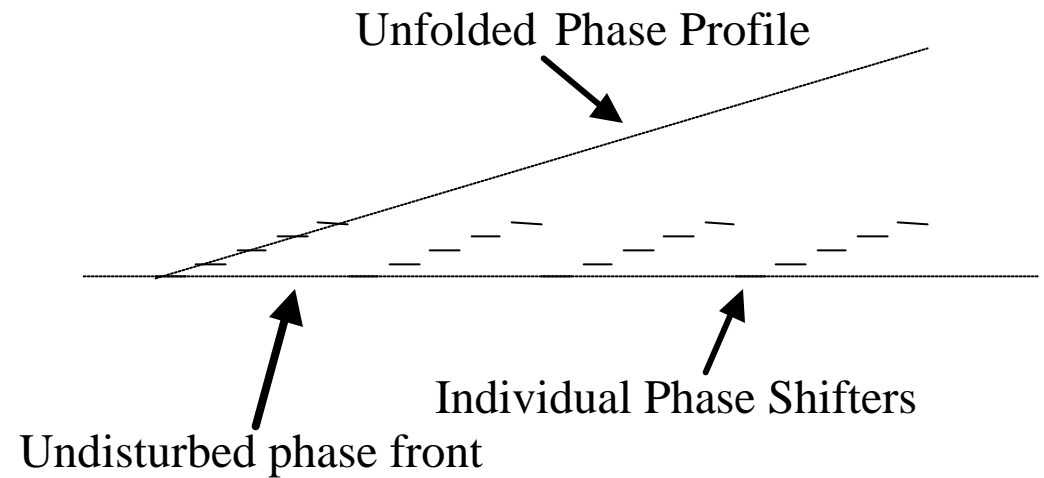
ERASER

- ID at Flir Detection Range
    - 20- 25 Km ID range, through a 20 cm diameter aperture
    – LANTIRN ID range is 4-5 km

- Use existing laser designator laser
    – Minor additional hardware compared to existing laser designator pods

- High Resolution TV-like Laser Reflectance Image
    – for Pilot
    – for ATR

- Flight Demonstrations
    – FY00 - 1.06 micron laser
    – FY01 - 1.54 micron laser (eyesafe)

JOANNA Concept
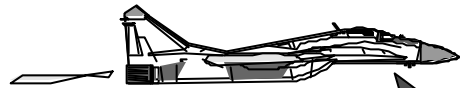
Multi-Spectral Imaging (MSI) for Target Detection
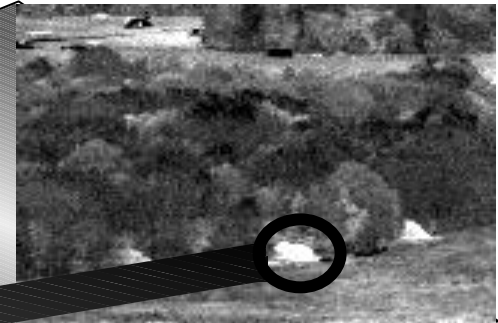
Laser Radar for Target Identification and False Alarm Reduction

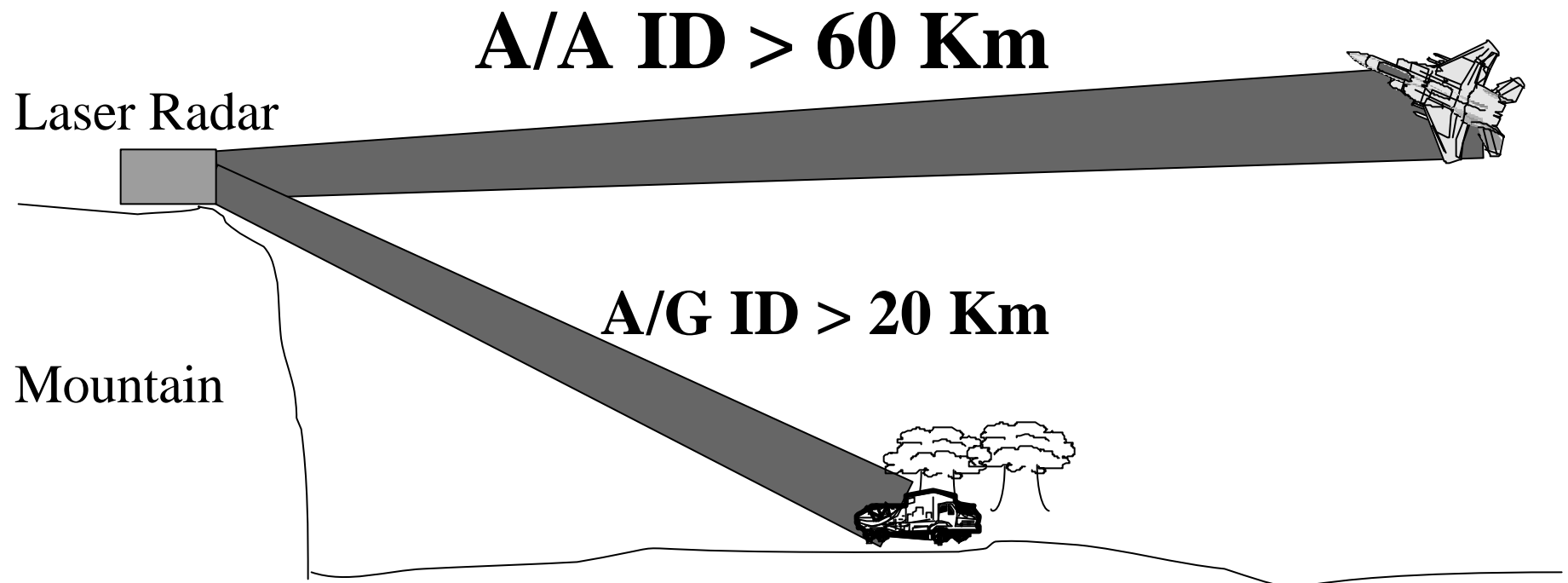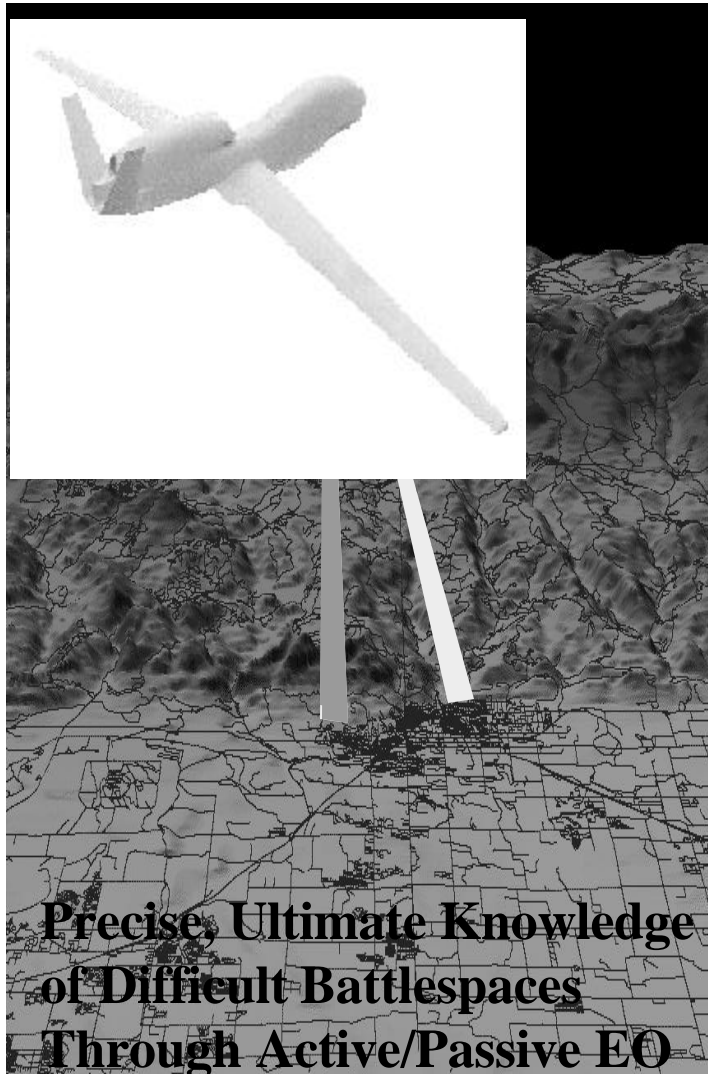# Planned Mountain Top Demonstration

Proof of Combat ID capability

A/A ID > 60 Km

Laser Radar

A/G ID > 20 Km

Mountain

Integrated EO on a UAV Platform

Potential Advanced EO-UAV Dissects BattleSpace

- **Precision 5-D Mapping**
    - Partition Space
    - Precision Urban Mapping
    - Change Detection
- **Active/Passive HSI & Polarization**
    - Finds Targets & Queue Ladar
    - Material/Geometry ID
    - Chemical Agent ID & Effluent Track
- **Imaging Vibration**
    - Ultra Sensitive Vibration Detection
    - Listen for Targets under Cover
    - UGF, Facility Monitoring/Activity
    - Decoy Detection
- **Multiple Look Signal Processing**
    - Reconstruction Under Cover
    - All Aspect Geometry
    - Fusion with Other Sensors
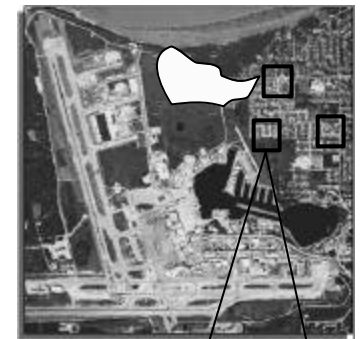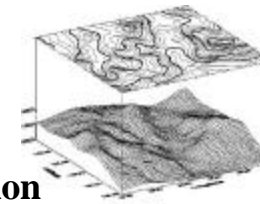
Single Multi-Function Ladar

N-D Imaging, Vibration, AMS, Polarization, Winds/Aerosol Tracking

Precise, Ultimate Knowledge of Difficult Battlespaces Through Active/Passive EO